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Page

The cover design represents the many computer-oriented new services at Western Union.

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international data/voice communications

H. F. Wilder

Western Union is providing an international data service over our Broadband Exchange Service, via the three overseas carriers to patrons in Great Britain and Europe. The success of this service is due to the cooperation of Western Union as a member of the CCITT with the overseas carriers in the United States, the foreign telegraph and telephone administrations and the equipment manufacturers.

C.C.I.T.T.

In 1959, the United Nations recognized the ITU, International Telecommunications Union, as the specialized agency authorized "to promote international cooperation for the improvement and use of telecommunications—and the development of technical facilities to provide telecommunications of increasing efficiency for public use." Article 29 of the ITU Convention, of that year, designated the International Telegraph and Telephone Consultative Committee (CCITT) as the authority which would collaborate with the International Standardization Organization ISO and the International Electro-technical Commission, IEC, in assuming responsibility for establishing standards for data transmission channels, signal converters (modems), and their interface with data processing equipments.

To carry out this task the CCITT established Special Study Group A which, first convened in Geneva in 1961 and again in 1963, reported to the third complete assembly of the CCITT in 1964. The Study Group A for 1963 comprised representatives from nineteen world-wide countries who were leaders in their respective telegraph and telephone administrations, or governments, and representatives from thirty-six incorporated communication carriers and manufacturers. Between 1961 and 1964 many technical studies were made by the participants of the Study Group. Ninety-four of these contributions have been published as "Supplements—concerning Data Transmission" in the Blue Book, Volume VIII published by the ITU in 1964.

Supplement No. 91 describes the Western Union Broadband Exchange Service and its advantages.[1, 3] Supplement No. 1, a multi-industry survey made in 1961 by the British Post Office, reveals a keen interest in data exchange, a need for error correction, and information retrieval, etc., all at transmission rates within the capabilities of voice-grade facilities. These ninety-four supplements are informative.

Overseas Communication Facilities

Overseas, only public switched telephone networks are available for data exchange. These networks, composed of voice-grade four-wire trunk circuits derived by frequency division between central offices, with transmission to a subscriber over a single conditioned cable pair, are 2-wire facilities. Transmission over telephone networks is characterized by distortion inherent to the band separation filters, and the loading coils in subscriber extensions. Attenuation in these extensions increases with frequency.

Echoes occur at the hybrid junction with the 4-wire trunks. Impulse noise generated by selector operating pulses in the exchanges may be encountered. Open-line intervals sometimes occur. However, serial data transmission studies made by several administrations, demonstrated that effective transmission, with acceptable error rates, could in general be obtained up to 1200 bauds without equalization of frequency and delay distortion. Also that higher speeds could be obtained only at the cost of providing system-wide corrections with specialized personnel.

In general practice each voice circuit is allotted a 4 kHz slot in the carrier multiplex; the amount of this narrow band made available for intelligence transmission depends upon the complexity and cost of the band selection filters. Figure I displays the unequalized frequency and delay distortion of a 2200 km circuit composed of three carrier systems between London and Rome. It may be noted that the optimum location of the carrier frequency of a double-sideband signal converter is 1700 Hz if both upper and lower sidebands are to suffer equal delay distortion. This distortion might be relatively ineffective if the component frequencies are confined to a spectrum about one-third as wide as the 4 kHz allotment. Broadband Exchange Service circuits are wider in spectrum and have been individually corrected for envelope delay distortion. By means of very sophisticated and more expensive filters a usable band of 2800 Hz is obtained from transatlantic telephone cable circuits with only a 3 kHz section in the cable spectrum. An Early Bird synchronous satellite channel has a net width of 3.2 kHz, and very great time delay.[4]

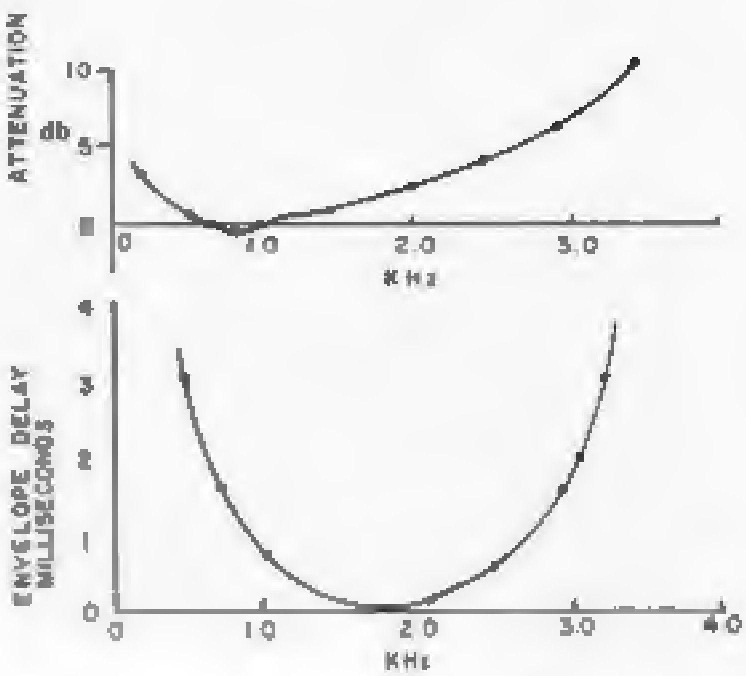

Fig. 1—Attenuation and Delay Three-Section VF System between London and Rome (unequalized)

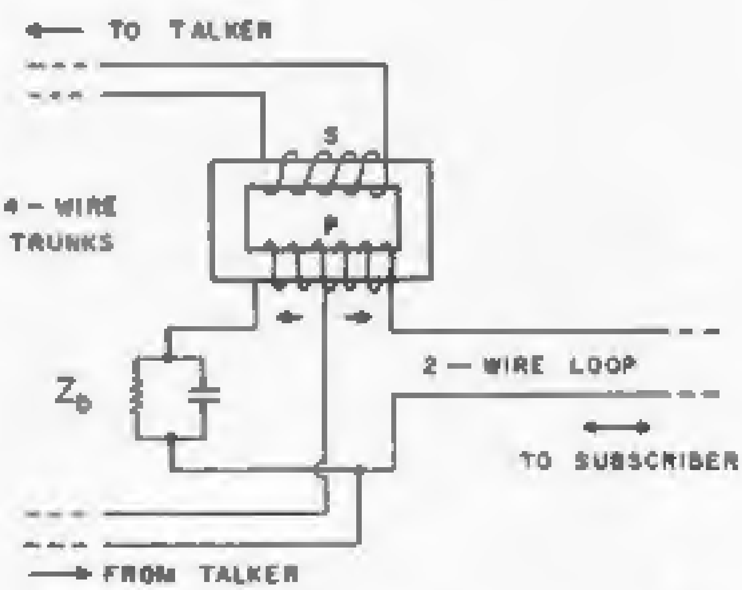

Fig. 2—Theoretical Equivalent Circuit of a Hybrid Junction

Echo Suppressors and their Disablement:

All Broadband Exchange Service subscribers in United States are connected to the service trunks by separate send and receive cable pairs to preserve the advantages of the 4-wire system. Overseas 4-wire trunks of the public switched telephone network are coupled by a hybrid or

Wheatstone Bridge to a single cable pair leading to the subscriber. Figure 2 is a theoretical circuit equivalent to the hybrid junction. Ideally, the balancing network Z_b matches the impedance of the 2-wire Line at all frequencies so that received current divides equally at the center of the transformer primary and no current is returned to the talker by induction. In practice Z_b is a simple compromise structure, but because there is appreciable unbalance some energy is returned to the talker. If both terminals are on a 2-wire basis and the system is without loss it may oscillate; with a fixed loss singing quickly dissipates. It should be emphasized, there are no reflections from the 4-wire Broadband Exchange Subscriber terminal.

Echoes degrade voice communication to a degree dependent upon the round-trip time of propagation of the circuit. If this delay is but a few milliseconds for a circuit, perhaps two hundred miles long, the echo will mingle with the sidetone in the subscriber's handset and will be tolerable; delays an order of magnitude greater require the insertion of echo suppressors. The round trip delay of a transatlantic New York to London cable VF is 73.5 milliseconds; a circuit to Germany via Early Bird seven times as great.[4]

Echo suppressors are inserted in the 4-wire trunks, preferably at both terminal offices, because of the long propagation times (greater than 45 milliseconds) encountered in overseas cables or transcontinental circuits. To effect echo suppression, separate amplifiers are bridged across the send and receive trunks and their rectified outputs passed differentially through, in effect, a three-state relav. The presence of speech currents in the transmit path for one-tenth of a syllable or about twelve milliseconds will cause the differential mechanism to insert 45 decibels attenuation in the receive path to dissipate the energy reflected by impedance mismatch at the hybrid. Removal of this loss is effected in about 70 milliseconds following cessation of speech. On circuits 2500 miles or longer it is desirable to insert suppressors at both terminals to speed up the turn-around.

Because medium speed data transmission (600 to 2400 bauds) utilize the greater portion of a voice band, data can be exchanged only in one direction at a time on a 2-wire system. In this type of operation where the data signals occupy most of the voice band, echo suppressors do not interfere with transmission. In practice it is desirable to provide a backward or supervisory channel for quickly correcting errors in response to an incorrect parity count at the receiving terminal. The slower speed supervisory channel occupies a narrow frequency slot, set off at the lower end of the voice spectrum by separation filters. It makes it necessary that all echo suppressors be disabled to clear a backward trunk path for the control signals.

The CCITT declares that echo suppressor disabling means shall respond to a pure tone of 2100 ± 15 Hz transmitted prior to data for at least 300 ms, at a level of −13 dbm, and that interruptions of the subsequent data transmission shall not exceed 100 ms if the disabling signal is not to be repeated.

The disabler associated with each echo suppressor is essentially a high-impedance frequency selective amplifier bridged across both trunks by means of a separation hybrid. One input path to the amplifier is sharply resonant at the 2100 Hz conditioning tone; another path whose rectified output is of opposite polarity to the first admits all frequencies but the narrow conditioning range. Consequently normal speech currents will not "talk off" the echo suppressor because of the neutralizing effect of the broadly-tuned guard band. Once attacked by the 2100 Hz tone the disabler output relay will be operated. Relay contacts disable the echo supressor so that it remains in its neutral state without insertion of loss in either trunk. Other contacts so broaden the disabler tuning that it remains operated irrespective of the frequency of data or supervisory channel energy in either trunk. About 100 ms after all energy has disappeared in both trunks, disablement of the echo suppressor will cease in anticipation of the resumption of voice coordination.

When disablers are not provided, the echo suppressors must be permanently deactivated and voice communication is degraded. It appears that automatic echo suppressor disablement will be necessary on satellite circuits, because of their excessively long double-time of propagation.

CCITT Recommendations

With the rapid growth of international communications since the last war, the CCITT has maintained the responsibility for defining standards for telephone and telegraph operation.[3] These standards are published in a series of "Recommendations" of which Series V of 1964 directly refers to data transmission.

Recommendation V. 1

Recommendation V. 1 describes the equivalence of binary notation symbols "1" and "0" to the significant conditions of a two-conditioned code. Table I tabulates this equivalence for amplitude and frequency-modulated carrier transmissions. Since all relations are the same in United States, compatibility with overseas transmissions is assured in these respects.

Recommendation V. 2

Power levels for data transmissions on voicebands are discussed in CCITT Recommendation V. 2. Its objectives are to secure effective data transmission and ensure the operation of echo suppressor disablers, and to prevent excessive noise levels caused by power overloading on the voice channel carrier multiplex systems. These objectives are often difficult to attain because of the wide variations in attenuation of subscriber loops of 2-wire systems. To guard, in some measure, against system overloads the maximum power output of the subscriber sending apparatus must never exceed 1 milliwatt or 0 dbm. Within this limit and in recognition of the often excessive loop attenuation, it is recommended that the output of phase or frequency modulated apparatus be adjusted in so far as possible to compensate for the loop loss and to deliver to the trunk serving the international connection a total nominal power not to exceed −10 dbm. On 2-wire systems using a simultaneous backward channel the CCITT provisionally recommends that total power be shared

Table I
Table of Equivalence for Two-condition Codes

	Two Conditions				
Codes	**Digit 0**		**To Line**		**Digit 1**
Amplitude Modulation	Tone Off	→		←	Tone On
Frequency Modulation	Higher Freq.	→		←	Lower Freq.
Battery Potential	Positive	→		←	Negative
Telegraphy	Spacing/Start				Marking/Stop
Tape	No Hole				Hole

equally between the data and supervisory channels to ensure satisfactory operation of echo suppressor disablers, and to maintain integrity of the supervisory path. Consequently, in the system considered the maximum power level at point of entry to international service for either the data or the supervisory channel is −13 dbm.

Recommendation V. 23

Because voice frequency circuits derived from multi-channel carrier systems will not transmit signal frequency components much below 300 Hz, a frequency converter or modem (modulator-demodulator) is interposed between the data-processing terminal equipment and the station inter-connecting voice circuit. The function of the modem is to translate frequency components in the data baseband signals, which range as low as zero frequency for steady Mark or Space, to alternating currents acceptable to the nominal 300 to 3400 Hz line pass-band.

Recommendation V. 23 describes the principal characteristics of a modem standardized for medium speed transmission of data in switched telephone networks. Results of tests reported in numerous contributions to Special Study Group A presume that effective data transmission will obtain at 600 bauds on dialed-up multi-section international telephone connections, and at 1200 bauds on all but those terminating in heavily loaded cable extensions. The choice of modulation reflects an earlier recommendation, that in the presence of noise and particularly if subject to sudden changes in signal power levels a frequency-modulation telegraph systems is least adversely affected.[5] To enable a data receiving station to send back to the data transmitting station signals essential to error control an optional 75 baud supervisory channel is specified so that both data and error control signalling can occur simultaneously on the 2-wire subscriber extensions. The supervisory channel is a standard CCITT FM narrow-band channel located outside the lower limit of the data transmission spectrum.

The characteristics of interest are:

Forward data-transmission channel,

Signalling Rate	Fo	F mark	F space
up to 600 bauds	1500 Hz	1300 Hz	1700 Hz
up to 1200 bauds	1700 Hz	1300 Hz	2100 Hz

Supervisory (backward) channel,

Rate	Fo	F mark	F space
up to 75 bauds	420 Hz	390 Hz	450 Hz

Received frequencies may on occasion suffer an off-set due to successive carrier modulation-demodulation processes in excess of the prescribed 2 Hz. Receivers should function over a level range of from −40 to 0 dbm. Receiving circuit integrity is to be monitored by amplitude-sensitive loss of carrier detectors: both alarm delay and restoration times are provisionally set at 10 milliseconds.

At the discretion of manufacturers a clock to pulse the data-processing terminal equipment, a signal regenerator, and a tone generator to disable echo suppressors may be provided optionally. No send level or receive sensitivity controls in the modem may be under control of the operator.

Recommendation V. 24

Development of data exchange on communication networks has been immeasurably assisted by standardization in United States and overseas of data and control signals passed between the data-processing terminal equipment or business machine and the modem under its control. Recommendation V. 24 of the CCITT defines the parameters and operational functions of some twenty-nine bipolar voltage interface circuits. The Electronic Industries Association publication ERS-232B independently describes most corresponding circuitry and the required 25-pin interconnecting plug and socket. Essentially, signal transitions across the interface shall be approximately rectangular with a rise time less than three per cent of pulse duration and must develop not less than ± 3 or more than ± 25 volts across an input resistance presented by the driven

Table II

Standard Interface Connections

DATA-PROCESSING TERMINAL EQUIPMENT					DATA COMMUNICATION EQUIPMENT-MODEM	
			TO → FROM ←			
		CCITT CKT. NO.		NAME	(EIA)	
DATA CHANNEL		1		PROTECTIVE GROUND	AA	
		2		SIGNAL COMMON RETURN	AB	
	DATA OUTPUT	3	→	TRANSMITTED DATA	BA	
		5	→	REQUEST TO SEND	CA	
		6	←	READY FOR SENDING	CB	CLEAR TO SEND
		7	←	DATA SET READY	CC	
		8	→	CONNECT DATA SET TO LINE	CD	D.T. READY
		13	→	TRANSMITTER TIMING	DA	
		14	←	TRANSMITTER TIMING	DB	
		16	→	TRANS. BLOCK TIMING		
		26	→	SELECT TRANS. FREQUENCY		
	DATA INPUT	4	←	RECEIVED DATA	BB	
		9	←	DATA CXR. DETECTOR	CF	
		10	←	DATA SIGNAL QUALITY	CG	
		28	→	RECEIVER TIMING	DC	
		15	←	RECEIVER TIMING	DD	
		17	←	RECVR. BLOCK TIMING		
		24	→	DATA RECVR. CUT-OFF		
		27	→	SELECT RECVR. FREQUENCY		
	SPEED	11	→	DATA RATE SELECTOR	CH	
		12	←	DATA RATE SELECTOR	CI	
SUPERVISORY CHANNEL	OUTPUT	18	→	TRANSMITTED DATA		
		20	→	TRANSMIT CARRIER		
		21	←	SUPVSRY. CHNL. READY		
	INPUT	19	←	RECEIVED DATA		
		22	←	CARRIER DETECTOR		
		23	←	QUALITY DETECTOR		
		29	→	RECEIVER CUT-OFF		
	SIGNAL	25	←	CALLING INDICATOR	CE	RING INDCTR.

electronic relay or modulator of between three to seven thousand ohms. Experience seems to favor a ± 12 volt sender having an internal impedance ranging from 300 to 2000 ohms so that the minimum control voltage is well exceeded

Table II tabulates these interface connections standardized by CCITT, and by EIA. One may expect near future standardization for a domestic supervisory channel and hopefully, common pin numbering. For those unfamiliar with a data exchange, a somewhat abbreviated procedure follows for a half duplex circuit terminating in a two-wire connection overseas: initially, the correspondents through the line voice equipment agree on speed and if in a higher range up to 1200 bauds will positively energize the Data Signalling Rate Selector lead, and then reverse the polarity to positive on the Connect Data Set to Line lead, thereby switching the lines from the telephone to the modem. At the receiving station, negative battery applied to the Request-to-Send lead will cut off the data transmitter carrier and temporarily "mark-hold" the supervisory receiver. Assuming that the station about to send data is equipped with an echo suppressor disabling module the application of positive battery to the Request-to-Send lead at that station will first cause a 400 millisecond burst of 2100 Hz tone to be transmitted followed by steady marking frequency. The supervisory channel transmitter is cut off at this time

Reception of the data transmitter tones enables the receiving terminal loss of Data Carrier Detector which starts the data processor equipments, releases the data receiver, and causes the supervisory channel transmitter to now send 390 Hz marking frequency back to the sender. There its arrival enables the Loss of Supervisory Carrier Detector which finally releases the data tape reader. At the conclusion of the data and backward error control transmissions the sending operator returns the Request-to-Send lead to negative suppressing the data carrier and thereby signalling the distant receiver by means of the Loss of Data Carrier alarm. Both operators regain voice coordination by switching the Connect Data Set to Line lead to "OFF."

Forward and Backward Modem

To assure compatability with modems abroad and complete operations versatility for international data/voice communications, Western Union selected the Type GH2002 Modem. This modem, shown in Figure 3, conforms to CCITT Recommendations V 23 and V 24 for the forward and backward channel modems and interface controls, and provides several useful options. Either asynchronous or synchronous operation may be elected; if the latter, a crystal-based clock to pulse the sending data processing terminal equipment and a receiving signal regenerator are available. To disable echo suppressors a READY FOR SENDING module may also be inserted in the rack, and depending on the type of line distortion encountered a compromise type of either delay or frequency distortion equalizer is available

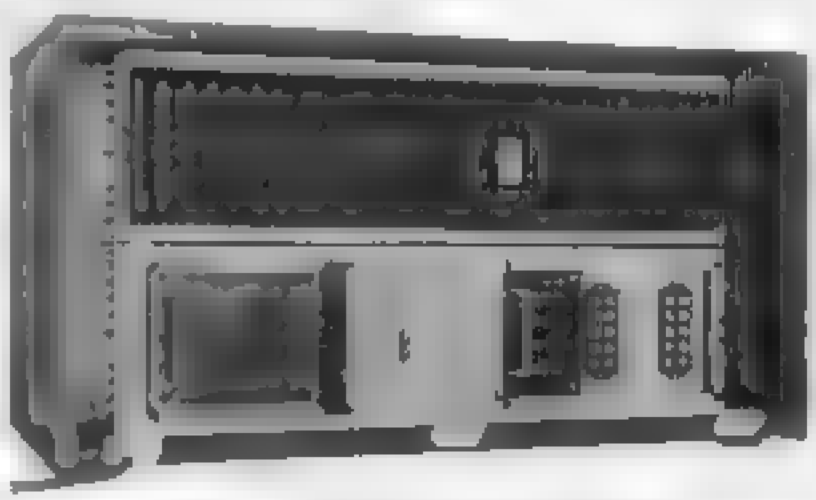

Figure 3—Type GH2002 Modem

The GH2002E 180 modem is manufactured by Standard Radio and Telefon AB of Solna, Sweden. The double modulation process permits the hypothetical carrier center frequency to be shifted to either 1500 or 1700 Hz by mutual consent of the operators in response to circuit speed limitations, and because the data baseband impulses first modulate a high frequency oscillator, keying jitter is eliminated. The high frequency carrier pulse spectrum is heterodyned by a translation oscillator to a band centered about 1500 to 1700 Hz for transmission to the line. At the receiver, the same oscillator shifts

the line spectrum to its original high range before driving the FM discriminator. When in this elevated state the amplitude of the carrier pulse envelope is affected by circuit noise and an amplitude sensor or QUALITY CONTROL is available, for either data or supervisory channel, which can be used in conjunction with character parity check by some business machines to increase the accuracy of error detection.

The modem is completely transistorized and reliable in performance. Its single variable element, a bias trimmer, and the plug-in attenuation controls of send power levels and Loss of Carrier Detectors sensitivities are not available to the operator. The latter affects all switching functions from the business machine over the standardized interface.

Frequency separation filters provide sufficient inter-channel attenuation to permit simultaneous operation of both data and supervisory channels and because of this, wholly domestic 4-wire simultaneous full duplex data circuits are contemplated. These circuits will permit the subscriber to exchange data and exercise error control in both directions simultaneously and will fully exploit the advantages of the 4-wire Broadband Exchange Service.

Data Processing Terminal Equipments:

Two tape-handling terminals are illustrative of asynchronous and synchronous data processors now operative overseas: Info Terminal 311 and Data Communication System GH 201. Asynchronous Info-Terminal 311 shown in Figure 4, manufactured by Tally Incorporated, contains some special features developed by Western Union to achieve operational versatility either domestically or overseas via Broadband Exchange facilities. When operated with on-line error detection and retransmission, the eighth level in the tape is perforated, or not, to obtain a constant odd, or even, number of perforations in each character. The transmission blocks contain a fixed number of characters chosen from 32 to 128 to exceed the one-way propagation time. A unique, no-print, end-of-block character provides separation. As will be explained it is advantageous to transmit the tape content generated by a manual perforator or business machine in the backwards sense. In Fig. 4 the tape reader is between the two reels. Reading is effected, step by step, with start and stop pulses added by internal circuitry of the terminal to constitute a ten-bit character. These modulate the carrier sent to line at either 600 or 1200 bauds, the demodulated start pulse restraining the receiving reperforator to synchronism character by character.

Figure 4—Info-Terminal 311

Following voice coordination the idle sending terminal transmits marking frequency carrier tone recognized at the receiving terminal by the Loss of Carrier Detector as a command to start motors and to turn on the Supervisory Channel Transmitter marking carrier tone. Reception of the latter at the sending terminal gives the operator the green light, literally, to start transmission on the forward data channel. When concluded, cut-off of the transmit carrier may signal the receiving operator.

An ingenious error correction cycle is employed by the Info-Terminal 311. If at the receiver, scan of a character shows ab-

sence of parity, it is, first deleted by punching all eight holes in the tape to achieve a "no print" condition; next a unique "flag" character is automatically punched to denote the end of an incomplete block containing a character in error; and then reperforation ceases. However, circuitry within the terminal continues to scan the still incoming characters for the end-of-block character and when it is sensed the polarity of the transmit supervisory channel lead is abruptly reversed. This reversal is recognized at the sending data terminal some tens of milliseconds later, as a command to reverse the direction of motion of the data tape in the reader

Receive terminal circuitry continues to scan the incoming characters now sent in reversed sequence, and soon counts two end-of block characters; the first, the one which just effected tape reversal, the second bracketing the block in error. Instantly, the supervisory signal is restored to normal polarity thus signalling the transmitter to again read the tape in normal forward motion. The first end-of block character thereafter received then signifies the beginning of a re-run of the original block in error and reperforation is at once enabled.

Later, when the reeled tape is fed directly to a business machine the flow of information will be correct in time frame, since it was originally transmitted backwards. However, the business machine must possess simple circuitry to reject all data between any unique "flag" and the next end-of-block character. If not so equipped, the Info-Terminal 311 has the capability to prepare a "clean" tape off line by sending to its own reperforator.

Data Communication System GH-201, manufactured by Standard Radio and Telefon AB. Solna, Sweden, is an efficient synchronous paper tape input/output terminal producing error-free tape at the receiving station. By the addition of two impulses to seven levels of prepared data information a double parity transmission code is obtained Used in conjunction with the signal detector positive error detection results.

At the sending GH-201 terminal protection is afforded to prevent transmission of characters lacking in parity and a continuously replenished store of those transmitted is maintained in a shift register. Detection at the receiver of a character in error is signalled to the data transmitter over the backwards supervisory channel and a sufficient number of characters retransmitted to effect reperforation of an automatically edited tape.

A Western Union Automatic Answering Unit in a Broadband Exchange receiver installation will provide unattended answering service for the systems just described and is often a distinct advantage in view of the great time differential overseas.

Overseas Interconnections:

Numbers of submarine cable circuits or satellite links derived by frequency division multiplex at the cable head or ground station are extended to each of the three inter-continental data carriers on national audio circuits. Each international carrier leases one or more subscriber terminals from Western Union to enter the Broadband Exchange network and thence its overseas data exchange customers. The voice-data handset enables the customer to request an overseas connection or respond to an international call. Since both intercontinental and Broadband circuits are 4-wire facilities two, two-conductor cord patches at a jackboard suffice to make a connection. Preliminary remarks to establish an overseas connection are passed between cable terminals over the data channel itself. At present each direction of data transmission is monitored by its own high input impedance amplifier and a loud-speaker to indicate aurally the call duration to the nearest six seconds and to enable immediate termination of completed calls.

Before the availability of Automatic Answering Unit 11774-A an overseas carrier might, because of the five hour or more time differential, reperforate a data transmission and retransmit it to the called correspondent at a more convenient hour. To some extent this practice is still carried on in the interest of data security

Broadband Network

Upwards of twelve or more transatlantic circuits are now operative via the Broadband network and overseas cable between subscribers in United States and the United Kingdom. Anticipating further growth in transatlantic communication the carriers are considering provision of semiautomatic switchboards to free the attendant to answer other calls and to effect automatic billing and circuit disconnection. To make the latter objective possible the nearest Broadband central exchange will be equipped with sensors monitoring the switching matrices to automatically transmit disconnect signals to the new switchboards.

The center frequencies of Western Union 600 and 1200 baud modems, Types 1601-B and 2121-B are at variance with those recommended by the CCITT. The center frequency of the Type 2121-B is 1800 Hz while that of the Type 1601-B was positioned at 1100 Hz for sub-band operation. A laboratory study to determine control circuitry for the GH2002E-180 modem has shown that since the signalling frequency shifts are essentially alike the required center frequencies of 1100 and 1800 Hz for domestic operations, and 1500 and 1700 Hz for overseas can be selected at will by minor changes in translation oscillator frequency. This facility is expected to enhance the value of the GH2002 modem to international voice/data subscribers and encourage their use of the Broadband Exchange Service within United States.

* * * *

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Harold F. Wilder, Supervisor of voice-frequency modems in the Information Systems and Services Department, has been concerned principally with the design and application of terminal apparatus for the Company's transatlantic cables. This experience has proved useful in the establishment of overseas high-speed data exchange.

Mr. Wilder holds seventeen patents on cable signalling, many of which have been described in technical journals.

He was fifth recipient of the F. E. d'Humy Award in 1959. This award was presented annually by Western Union to the technical employee who had made the most significant contribution to the telegraph art. He has been honored as a fellow in I.E.E.E. since March, 1967.

revised

U.S.A. standard code for information interchange

Fred W. Smith

INTRODUCTION

The U S.A. Standard* Code for Information Interchange, described in the April 1964 issue of the TECHNICAL REVIEW, has been revised to include the lower case of the alphabet, and to incorporate other changes which will make the code more useful for both communications and data processing The revision provides controls not included in the original ASCII, and includes changes intended to achieve compatibility with a proposed international standard 7-bit coded character set. The revised code was approved by the U S.A. Standards Institute on July 7, 1967.

In the revised code, shown in Table I, the eight columns are numbered 0 through 7, from left to right, where the column number is the decimal equivalent of the binary number formed by the three high order bits, b_7, b_6, and b_5. Similarly, the rows are numbered 0 through 15, from top to bottom, with the row number being the decimal equivalent of the binary number formed by the four low order bits. b_4, b_3, b_2, and b_1. Any character in the code may therefore be represented by giving its position in the table. For example, the capital letter A may be identified by the notation "column 4, row 1", or simply by 4/1

TABLE I

REVISED US ASCII CODE (X3.4 - 1967)

ROW ↓	b_4 ↓	b_3 ↓	b_2 ↓	b_1 ↓	COLUMN → 0	1	2	3	4	5	6	7
				b_7 →	0	0	0	0	1	1	1	1
				b_6 →	0	0		1	0	0	1	1
				b_5 →	0		0	1	0	1	0	1
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
1	0	0	0	1	SOH	DC1	!	1	A	Q	a	q
2	0	0	1	0	STX	DC2	"	2	B	R	b	r
3	0	0	1	1	ETX	DC3	#	3	C	S	c	s
4	0		0	0	EOT	DC4	$	4	D	T	d	t
5	0	1	0	1	ENQ	NAK	%	5	E	U	e	u
6	0	1	1	0	ACK	SYN	&	6	F	V	f	v
7	0	1		1	BEL	ETB	'	7	G	W	g	w
8		0	0	0	BS	CAN	(	8	H	X	h	x
9	1	0	0	1	HT	EM	)	9	I	Y	i	y
10	1	0	1	0	LF	SUB	*	:	J	Z	j	z
11	1	0	1	1	VT	ESC	+	;	K	[	k	{
12	1	1	0	0	FF	FS	,	<	L	\	l	|
13	1		0		CR	GS	-	=	M	]	m	}
14	1	1		0	SO	RS	.	>	N	^	n	~
15	1	1	1	1	SI	US	/	?	O	_	o	DEL

*Effective August 24, 1966, the American Standards Association was reconstituted as the United States of America Standards Institute. Henceforth, American Standards, including those approved prior to the change in organization of the Institute, will be known as U S.A. Standards.

Abbreviations in Table I

NUL—Null
SOH—Start of Heading
STX—Start of Text
ETX—End of Text
EOT—End of Transmission
ENQ—Enquiry
ACK—Acknowledge
BEL—Bell (audible or attention signal)
BS—Backspace
HT—Horizontal Tabulation
LF—Line Feed
VT—Vertical Tabulation
FF—Form Feed
CR—Carriage Return
SO—Shift Out
SI—Shift In
DLE—Data Link Escape
DC1—Device Control 1
DC2—Device Control 2
DC3—Device Control 3
DC4—Device Control 4 (stop)
NAK—Negative Acknowledge
SYN—Synchronous Idle
ETB—End of Transmission Block
CAN—Cancel
EM—End of Medium
SUB—Substitute
ESC—Escape
FS—File Separator
GS—Group Separator
RS—Record Separator
US—Unit Separator
SP—Space
DEL—Delete

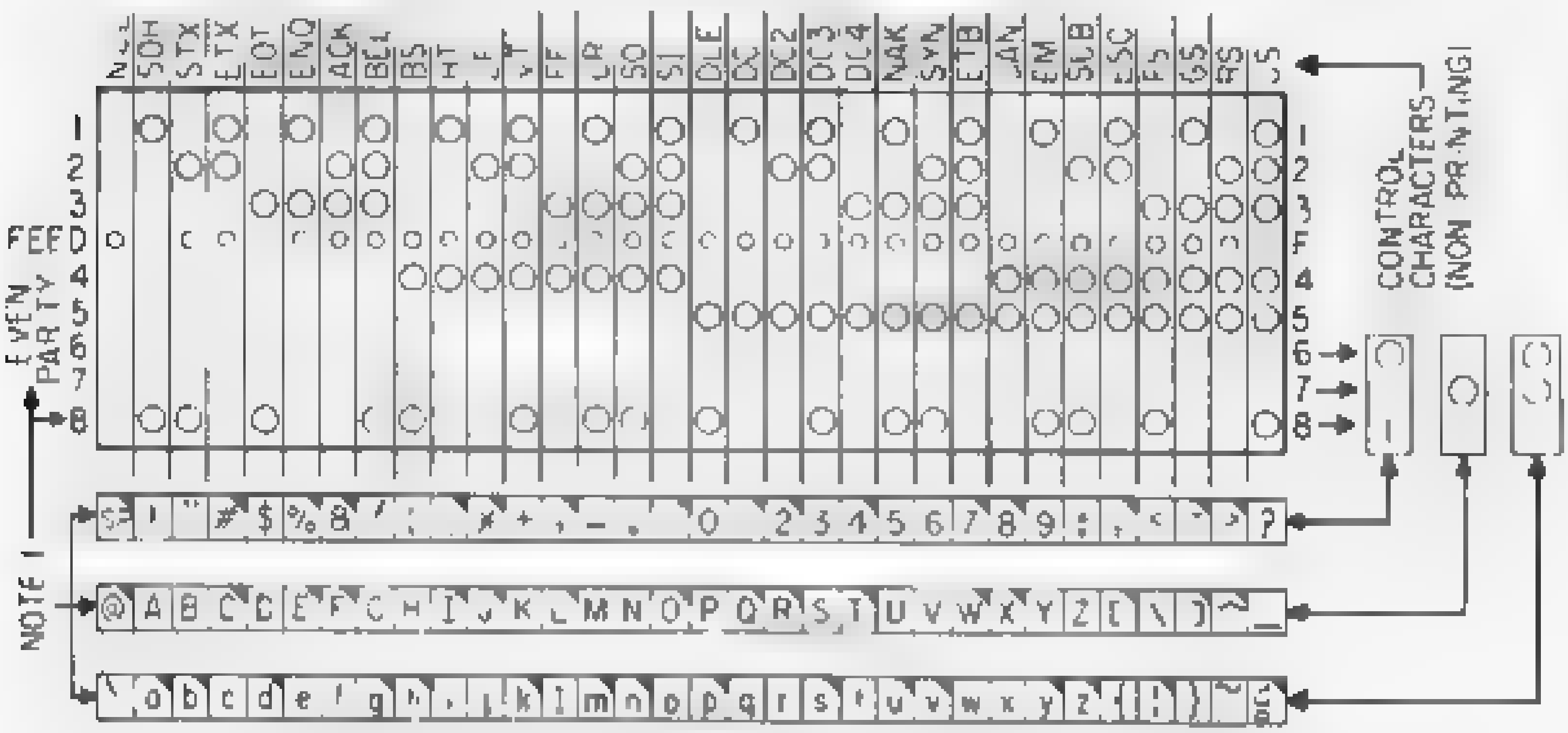

Fig. 1—8 Level Tape

Notes 1:

1.—[symbol]—Bit 8 is marking for even parity (hole punched)

2.—DEL—Delete is a non-printing character

TABLE II
ORIGINAL ASCII CODE

b_4	b_3	b_2	b_1	b_7 0 / b_6 0 / b_5 0	0 / 0 / 1	0 / 1 / 0	0 / 1 / 1	1 / 0 / 0	1 / 0 / 1	1 / 1 / 0	1 / 1 / 1
0	0	0	0	NULL	DC_0	[illegible]	0	@	P	UNASSIGNED	UNASSIGNED
0	0	0	1	SOM	DC	!	1	A	Q		
0	0	1	0	EOA	DC_2	"	2	B	R		
0	0	1	1	EOM	DC_3	#	3	C	S		
0	1	0	0	EOT	DC_4 STOP	$	4	D	T		
0	1	0	1	WRU	ERR	%	5	E	U		
0	1	1	0	RU	SYNC	&	6	F	V		
0	1	1	1	BELL	LEM	' (APOS)	7	G	W		
1	0	0	0	FE_0	S_0	(	8	H	X		
1	0	0	1	HT/SK	S_1	)	9	I	Y		
1	0	1	0	LF	S_2	*	:	J	Z		
1	0	1	1	VT/TAB	S_3	+	;	K	[		
1	1	0	0	FF	S_4	, (COMMA)	<	L	\		ACK
1	1	0	1	CR	S_5	− (MINUS)	=	M	]		[illegible]
1	1	1	0	SO	S_6	. (PERIOD)	>	N	↑		ESC
1	1	1	1	SI	S_7		?	O	←		DEL

Figure 1 shows an 8-level tape perforated with the new code. The 8th level was added to provide an even vertical parity check bit. Although the code standard does not provide for the use of a parity bit, a separate U.S.A. Standard (Perforated Tape Code for Information Interchange, X3.6-1965) specifies that, in perforated tape, a parity bit shall be recorded in the number 8 track and shall be chosen to provide an even number of code holes for each character.

Graphics versus Control Characters

In the original ASCII, shown in Table II, 28 unassigned characters were reserved for future standardization. During development of the revised code, one of the first problems to be resolved was whether the unassigned positions should be used for control characters or for graphics. Some sophisticated communications systems require more controls than those assigned in the original ASCII code. On the other hand, the need for a lower case alphabet in the unassigned area was recognized. Serious consideration was given to the use of shift and unshift characters, as in the 5-level Baudot code, to obtain lower case letters. It was decided, however, that the advantages, in data processing, of a nonambiguous code (i.e., one in which every bit permutation has a unique interpretation) outweighed the advantages to be derived from inclusion of additional control characters.

Concurrently with the X3.2 code standardization work, a 7 bit code was being developed by the International Organization for Standards (ISO) and the International Telegraph and Telephone Consultative Committee (CCITT). Representatives of X3 2 participated in this development and attempted to develop a U S A. Standard which would be compatible with the proposed International Standard (A revised ASCII code was approved in 1965 by what was then the American Standards Association. Release of this code was withheld partly because of international considerations and the 1965 version of the code was never published).

International Code

Many foreign language alphabets contain more than 26 letters. Some foreign languages also require the use of diacritical marks. In the proposed international code provisions for accommodating these languages have been made. Seven characters have been reserved for national usage. These seven characters are not to be used in international information interchange without prior agreement between the sender and the recipient. (Precedent for this exists in the CCITT No. 2 code, which reserves the upper case F, G, and H characters for national use[2])

The seven national use characters, with their location and assignment in the revised code, are:

Col./Row	Graphic Representation	Meaning
4/ 0	@	Commercial at
5/11	[	Opening bracket
5/12	\	Reverse slash
5/13	]	Closing bracket
7/11	{	Opening brace
7/12	|	Vertical line
7/13	}	Closing brace

In order to conform to the proposed ISO standard, one diacritical mark, the circumflex in 5/14, was also included in the revised US ASCII. Provision was also made in the standard to permit use of five punctuation symbols as diacritical marks. Some users of the code may design special type fonts which will facilitate use of these graphics for either purpose. These symbols are

Col./Row	Graphic Symbol	Punctuation	Diacritical
2/2	"	Quotation	Diaresis
2/7	'	Apostrophe, or closing quotation	Acute accent
2/12	,	Comma	Cedilla
6/0	`	Opening quotation	Grave accent
7/14	~	Overline	Tilde

These graphic symbols may be used as punctuation marks, but when used in conjunction with backspace (BS) they take on the meaning of diacritical mark. The overline is represented in the code table by a wavy line intended to indicate its use as a general purpose overline

The revised standard also permits the use of the pound sign (£) in lieu of the number sign (2/3) when the number sign is not required. The international standard, when finally adopted, will probably specify that these two signs are currency symbols and do not necessarily mean United States dollars or British pounds sterling. The current proposed international standard also permits displacement of three additional characters in those countries which require more alphabetic extenders. These three are the circumflex (5/14), the grave accent (6/0), and the overline (7/14). All of the alphabetic extenders are thus within the graphic subset, since data manipulation requirements make it essential to have a dense graphic subset.

Graphic Subset

The logic behind placement of the graphics in columns 2 through 5 of the code table in order to satisfy the requirements for ordering, collating, and sequencing operations in data processing systems was explained in the previous article[1]. Data processing requirements also influenced placement of the graphics in columns 6 and 7 of the code table. The lower case alphabet was placed so that a simple comparison of binary codes can be used to order information in a desired sequence. The 26 lower case letters were placed in columns 6 and 7, and arranged in increasing binary sequence from a to z. Each lower case letter was placed in the same row as the corresponding upper case letter. This arrangement resulted in a simple one-bit difference between upper and lower case letters. Dual case keyboards for generating the code can therefore be designed to generate upper case letters by using a shift key to invert bit 6: that is, to convert bit 6 from a one to a zero.

The non-alpha characters were placed in column 7 to obtain logical pairings with corresponding characters in column 5. For example, deleting (or inverting) bit 6 will change the bit permutation for the opening brace to that for the opening bracket. Similarly, the closing brace "folds into" the closing bracket. The vertical line in column 7 is paired with the reverse slash in column 5; and the overline is paired with the circumflex, which is also an overline character. The underline in column 5 was paired with delete (DEL), a non-graphic character.

The broken vertical line in position 7/12 will probably be widely used as either the "logical or" symbol, or to indicate "the absolute value of." The overline in position 7/14 will probably be used in many systems to indicate logical negation or complementation; in some devices, it will very probably be printed as a straight overline.

Design of keyboards for implementing the revised US ASCII will be somewhat more complex than the monocase ASCII keyboards (The Teletype Models 33 and 35) now used by Western Union. In dual case keyboards, the shift key must invert bit 6 when operated in conjunction with a key assigned to one of the graphics in column 6 or 7, and invert bit 5 when used to generate a shift character in column 2 or 3. Design of a strictly mechanical keyboard, such as the Model 35, for generating the revised US ASCII may prove to be uneconomical[3]. However, a keyboard similar to the Model 33 will require relatively simple logic.[4]

In developing the original ASCII, Subcommittee X3.2 attempted to include the characters commonly encountered in programming languages. All of the graphics in COBOL were included. The revised US ASCII includes all of the graphics used in both the COBOL and FORTRAN programming languages.

Control Characters

The international considerations previously discussed, coupled with the requirements for logical pairing of graphics, necessitated relocation of three control characters originally assigned to column 7. See Table II. The acknowledge (ACK) character was moved from position 7/12 to 0/6 and escape (ESC) from 7/14 to 1/11. The unassigned control in 7/13 was dropped. Removal of these controls

from column 7 was desirable for two additional reasons. First, it is desirable in data processing systems to identify quickly different classes of graphics and controls. In the revised code, if bits 6 and 7 are both zeros, the character is a control. If bit 6 and/or bit 7 is a one, the character is a graphic. The one apparent exception to this is delete (DEL) which, strictly speaking, is neither a control nor a graphic. Secondly, the change was desirable because a short open, or "hit," on a communications circuit is most likely to generate a character in column 7. Generation of a false graphic is generally a less serious error than generation of a false control.

There are four major classes of controls included in the new code: communications controls, format effectors, device controls and information separators. In addition, there are nine miscellaneous or unclassified controls. Table III lists these new controls and compares their new name with their old abbreviation.

In order to place the acknowledge (ACK) and escape (ESC) characters in columns 0 and 1, as well as to provide for additional controls, four of the eight information separators and the "are-you—" character included in the original code were dropped from the code table. The ACK was placed in the position vacated by the RU in order to obtain the maximum practicable bit difference between ACK and NAK. All of the communications controls are therefore located in the upper half of columns 0 and 1. ESC, which is not a communications control, was placed in the position vacated by information separator 3. The original logical-end-of-media (LEM) character was changed to "end of transmission block".

The remaining minor changes in the controls reflect a more general usage for the controls. Examples of this are the change of who-are-you to enquiry (ENQ) and the change from start of message (SOM) to start of heading (SOH).

TABLE III

COMPARISON OF OLD AND NEW CONTROL CHARACTERS

Col./Row	Old	New
	Communications Controls	
0/1	SOM	SOH—Start of heading
0/2	EOA	STX—Start of text
0/3	EOM	ETX—End of text
0/4	EOT	EOT—End of transmission
0/5	WRU	ENQ—Enquiry
0/6	RU	ACK—Acknowledge
1/0	DC_0	DLE—Data link escape
1/5	ERR	NAK—Negative acknowledge
1/6	SYNC	SYN—Synchronous idle
1/7	LEM	ETB—End of transmission block
	Format Effectors	
0/8	FE_0	BS—Backspace
0/9	HT SK	HT—Horizontal tabulation
0/10	LF	LF—Line feed
0/11	V_{TAB}	VT—Vertical tabulation
0/12	FF	FF—Form feed
0/13	CR	CR—Carriage return
	Device Controls	
1/1	DC_1	DC1—Device control 1
1/2	DC_2	DC2—Device control 2
1/3	DC_3	DC3—Device control 3
1/4	DC_4 (Stop)	DC4—Device control 4
	Information Separators	
1/12	S_4	FS—File separator
1/13	S_5	GS—Group separator
1/14	S_6	RS—Record separator
1/15	S_7	US—Unit separator
	Miscellaneous, or Unclassified Controls	
0/0	NULL	NUL—Null, or all zeros
0/7	BELL	BEL—Bell, or alarm
0/14	SO	SO—Shift out
0/15	SI	SI—Shift in
1/8	S_0	CAN—Cancel
1/9	S_1	EM—End of medium
1/10	S_2	SUB—Substitute
1/11	S_3	ESC—Escape
7/15	DEL	DEL—Delete

As previously stated, four information separators were eliminated in revising the code. The remaining four were assigned the specific functions of file separator, group separator, record separator, and

unit separator. These four separators are arranged in hierarchical order, with the file separator being the most inclusive and the unit separator the least inclusive. These four characters are contiguous with SP (space), which can also be used as an information separator. When space is so used, it is, of course, lower in hierarchical order than the unit separator.

Four changes were made in the unclassified controls. The escape (ESC) character was relocated from 7/14 to 1/11, as previously described. The cancel (CAN) character was placed in position 1/8 and defined as a control character used to indicate that the data with which it is sent is in error or is to be disregarded. The end-of-medium character (EM) was placed in position 1/9. This character serves the same purpose as the logical-end-of-media (LEM) character in the original code. It is used to identify the used, or wanted, portion of data recorded on a medium.

In the original code, the direction and use of the error (ERR) character were not specified. In the revised code, ERR has been replaced by NAK, which is a back acting control used to indicate to the sender that the recipient has received an error. The new SUB character in position 1/10 is a forward-acting control which can be substituted for a character which is determined to be invalid or in error.

In systems requiring control characters not included in the code, code extension techniques can be used to obtain additional controls. The data link escape (DLE) character in position 1/0 is intended to provide supplementary controls in data communications networks. The escape character (ESC) can be used to generate additional controls and it is not restricted to generating any one class of controls.

Dual case input/output equipment

The Teletype Corporation has already designed a teleprinter, the Model 37, for implementing the new dual case US ASCII code. These new teleprinters are expected to be available in production quantities during the second quarter of 1968. A Model 37 ASR set is also under development and is expected to be available in late 1968. Other companies will undoubtedly market dual case teleprinters, ASR sets, and other input/output equipment for implementing the new code in the near future. The keyboard is shown in Fig. 2.

In addition to printing both the upper and lower case of the alphabet, the Model 37 will incorporate many features never before available in a teleprinter. For example, it will be capable of on-line backspacing, reverse line feed, half-line feed, and reverse half-line feed. (Code extension techniques will be employed to permit special "stunts" such as reverse line feed and forward and reverse half-line feed). These features will permit the typing unit to print mathematical equations, chemical formulas, charts, diagrams, and graphs from signals received from either a tape transmitter or a computer.

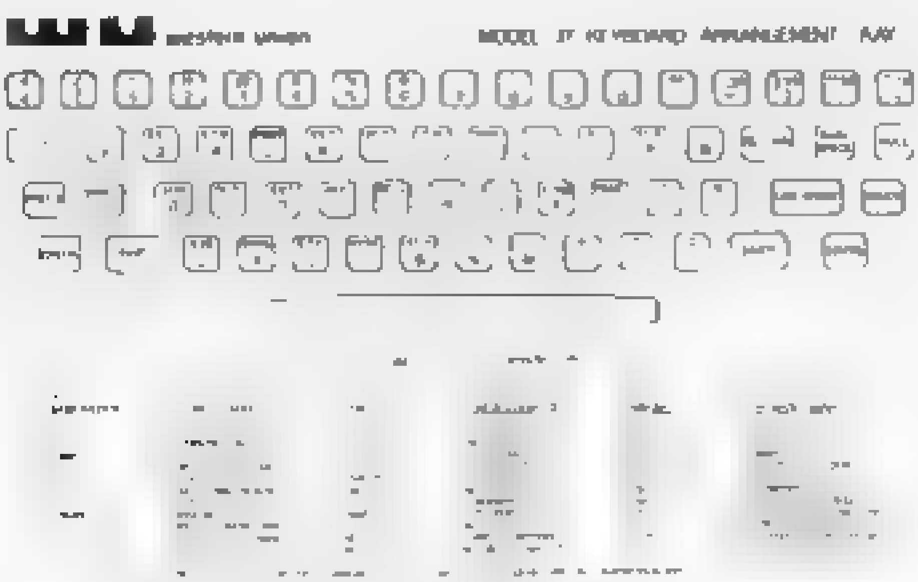

Fig. 2 — Model 37 Keyboard Arrangement

Since Western Union plans to use the Model 37 in future systems, the question naturally arises as to the compatibility with existing monocase Models 33 and 35 equipment. In those systems where monocase US ASCII teleprinters are to be used to transmit to and receive from the dual case Model 37, the Models 33 and 35 will have to be modified. The modifications will consist mostly of changes in key tops and type pallets. In existing systems which use the "RU" and/or the "ESC" control characters, it will also be necessary to make changes in the keyboard code bars and the stunt box function levers because of the changes made in the control characters when the code was revised.

After a Model 33 or 35 has been modified to conform to the revised code, it can transmit to or receive from a Model 37 teleprinter. A monocase teleprinter can, of course, transmit only the upper case alphabet; it cannot transmit the lower case alphabet or the special graphics in columns 6 and 7 of the code table. Conversely, it can print only the upper case alphabet when signals are received from a Model 37. If a Model 37 transmits lower case letters to a Model 33 or 35, the latter will convert all lower case letters to upper case, since both the Models 33 and 35 ignore bit 6 in positioning the typing mechanisms.[3,4] Similarly the five special symbols in columns 6 and 7 of the code table will be converted to the corresponding characters in columns 4 and 5.

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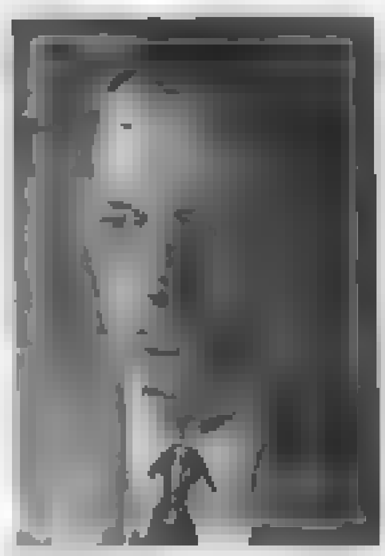
1. New American Standard Code for Information Interchange, by Fred W. Smith, Western Union Technical Review, April 1964, Vol. 18, No. 2.
2. European Teleprinter Developments, by Fred W. Smith, Western Union Technical Review, October 1960, Vol. 14, No. 4.
3. 8-Level Teleprinters and ASR Sets, Part I—Model 35, by Fred W. Smith, Western Union Technical Review, April 1965, Vol. 19, No. 2.
4. 8-Level Teleprinters and ASR Sets, Part I—Model 33, by Fred W. Smith, Western Union Technical Review, January 1965, Vol. 19, No. 1.



FRED W. SMITH, Equipment Engineer in the IS&S Department, is a member of the USA Standards Institute's Subcommittee X3.2, which developed the revised US ASCII code. He is also Chairman of Task Group X3.2.2B on perforated tape and a member of the Task Group on edge-punched cards.

Mr. Smith received a degree of Bachelor of Science in Electrical Engineering from Georgia Institute of Technology in 1938. He is a member of the Institute of Electrical and Electronics Engineers and has been Chairman of both the American Institute of Electrical Engineers Committee on Telegraph Systems and the AIEE Committee and Standardization of Perforated Tape.

definitions of new terms

Editor's Note: Because of the many requests from our Western Union field personnel for a Glossary of Terms—the following "new terms" used in the operation of Western Union's new services, are defined.

Cancel	A control character used to indicate that the data with which it is sent is in error or is to be disregarded.
COBOL	An acronym for **CO**mmon **B**usiness **O**riented **L**anguage, a computer language used in business data processing.
Communications control	A functional character intended to control or facilitate transmission of information over communication networks.
Delete	The "all ones" character which is used primarily to "erase" or obliterate erroneous or unwanted data in perforated tape.
End-of-medium	A control character associated with the sent data which may be used to identify the physical end of the medium or the end of the used, or wanted, portion of information recorded on a medium. (The position of this character does not necessarily correspond to the physical end of the medium.)
End-of-text	A communication control character used to terminate a sequence of characters started with STX and transmitted as an entity.
End-of-transmission block	A communication control character used to indicate the end of a block of data for communication purposes. ETB is used for blocking data where the block structure is not necessarily related to the processing format.
Enquiry	A communication control character used in data communication systems as a request for a response from a remote station. It may be used as a "Who Are You" (WRU) to obtain identification, or may be used to obtain station status, or both
FORTRAN	An acronym for **FOR**mula **TRANS**lation, a computer language used in scientific and engineering problems.
Negative acknowledgement	A communication control character transmitted by a receiver as a negative response to the sender
Null	The "all zeros" character which may serve to accomplish time fill and media fill.
Start of heading	A communication control character used at the beginning of a sequence of characters which constitute a machine-sensible address or routing information. Such a sequence is referred to as the "heading." An STX character has the effect of terminating a heading.
Start of text	A communication control character which precedes a sequence of characters that is to be treated as an entity and entirely transmitted through to the ultimate destination. Such a sequence is referred to as "text." STX may be used to terminate a sequence of characters started by SOH
Substitute	A character that may be substituted for a character which is determined to be invalid or in error

international data communications

AMA Seminar Sept. 20-22, 1967

Editor's Note: These excerpts have been taken from speeches made by a panel of experts who discussed the future of data communications worldwide at the AMA seminar

Four of the eleven speakers described systems currently in operation, the remaining seven speakers—being two each from ITT, RCA and IBM, and one from COMSAT In his keynote address, Mr. Bakst quoted Kappel, former Chairman of the Board of AT&T, as having predicted that data traffic would exceed voice communications before 1970. He further:

— cited decrease in costs and increase in speed of computers as accelerating this trend.

— noted comparison of speeds of voice versus data transmission as a strong economic factor favoring growth of data communications.

Mr Andres echoed Mr. Bakst's comment on the impact of computer usage on message traffic, noting that:

— only thirty data terminals were in use in the entire U. S. in 1958,

— 40,000 data terminals were in use in the U S. in 1966,

— a projected 100,000 data terminals will be in use in the U. S. by 1972

James Thompson, of COMSAT, traced the development of communication satellites stressing the decrease in costs achieved to date

Noting that data traffic currently comprises a greater percentage of total traffic in satellite communications than is true of ocean cable communications, he offered the following generalizations:

— lower speed lends itself to inquiry applications such as inventory control and other transaction oriented, (i. e., real time or on-line) data processing;

— high speed transmission is most frequently associated with batch processing operations; and

— the high cost of 48 or 40.8 kc transmission is frequently a bar to economic justification of data communication systems, and the high speed is generally needed only to handle peak period traffic.

Robert Dooley, of Pan American Airways, provided the highlight of the seminar—a live demonstration of Interpolated Data and Speech Transmission (IDAST). The demo consisted of a call to the Pan Am operating facilities in San Juan, P R , with the other end of the conversation being broadcast over the public address system. IDAST, as the name implies, is a system wherein the voice is recorded and held on a magnetic drum for 600 milliseconds, during which the pattern is analyzed by computer program and data bursts inserted in the unused time slots These data bursts were audible in the form of unobtrusive beeps.

The gist of Mr. Dooley's other comments included.

— Pan American's high speed data network is the world's largest privately owned network currently in operation,

— the network consists of seven 2,000 Baud circuits switched by an IBM 7050, has a three second response time and handles an average of 80,000 messages in and 94,000 messages out per 24 hour day;

— an industry shared telephone network is now in the talking stage.

Brigadier General Stoney reported on AUTODIN as follows.

— no on-line computers have been interfaced to the switched system to date—the Air Force uses dedicated lines for computer-to-computer transmission.

— a tremendous increase in traffic has occurred since initialization of system. The system was flooded recently by entering of one 7,000,000 character message which was broadcast to all stations. Upon investigation it turned out to be a magnetic tape containing revisions to a parts catalogue; solution: message was scraped and magnetic tapes were flown to critical areas and mailed to all others.

— level chasing causes hours of lost time on circuits, impacting the system. General Stoney recommended that monitoring be automated wherever possible and that trouble-shooting of facilities be done in parallel instead of serially. This statement illicited considerable comment from members of the audience, the gist of which was that refunds for outages merely serve to call attention to time lost and do not really compensate for loss of circuits—evidently a sore point.

Richard Thiel reported on IBM's internal telecommunications system as follows:

— Message and voice grade leased circuits currently totalling almost 1,000,000 circuit miles.

— Approximately 15,000 miles of 48 kc circuits.

— A closed circuit TV currently comprising 1,000 circuit miles.

— Terminal facilities vary in type from keyboard entry to magnetic tape and in speeds from 7 to 5,100 cps.

— Five major types of communications systems share portions of the total IBM communications network:

(1) An internal telegraph network used for both administrative and data traffic.

(2) A medium to high speed magnetic tape, card and computer transmission network.

(3) A number of conversational (man/machine) systems, e.g., Quiktran, Administrative Terminal Systems, Computer Assisted Instruction and Internal Management Information Systems.

(4) A fascimile network linking major headquarters, plant and laboratory locations.

(5) A limited closed circuit TV network.

— Computer message switching system for telegraph traffic, IBM 7740, soon to be replaced by S/360 Model 50 using CCAP.

— From 2 million annual messages in 1963, the system is now handling over 5 million messages with a projected volume of over 14 million messages per year by 1970.

— Opinions from other DP manufacturers, including IBM, supported Western Union projections of:

(1) Growth in communications based EDP systems from 5% of all U.S. installations in 1966, to 60% in 1965, and 95% by 1980.

(2) While W.U. leased circuits for voice traffic will double between 1966 and 1975, circuits used for transmitting data will grow by a factor of 100.

(3) While in 1962 only 3.2% of W.U.'s revenue could be attributed to data communications, by 1975, this share is expected to grow to 35%.

Mr. Thiel supported this statement with the following comments:

"Today, there is hardly a third generation system in the marketplace that has not been designed with communications capability. An increasing number of systems sold are actually hooked up to perform a data communications application. Within the next several years, a large percentage of those users who today do not use this capability will expand and integrate their equipment and enhance them as communication based systems . . ." ■

AAMP

autodin automatic maintenance program

—a software system

W. R. La Bar

AAMP, an acronym for the AUTODIN Automatic Maintenance Programs, is a series of programs in a software system developed to enhance the maintenance goal of AUTODIN. This goal is to have the redundant off-line equipment ready to assume on-line posture, and to minimize the time necessary to pinpoint hardware malfunctions.[1] AAMP consists of several programs one of which, the EXERCISOR, exercises the maximum amount of logic feasible and still maintains the Stand-By status of the equipment.* In the event of a malfunction during exercising, the appropriate diagnostic program is automatically called in to diagnose the malfunction. The diagnostic programs localize troubles to the smallest increment of hardware logic feasible within the confines of the introspection capabilities of the equipment.

RAISON D'ETRE

With the delivery of the initial AUTODIN equipment, maintenance aid programs in the form of Test and Maintenance (T&M) routines were provided to Western Union by the subcontractor. These T&M's written for every piece of equipment, tested a specific portion of the hardware. However, they did little to help the maintenance man localize a particular malfunction, since they were not written with this objective in mind. Their sole objective was only to provide confidence that the equipment was fully operable. At first, this point was questionable. However, later deliveries of equipment showed that the T&M's did improve considerably, but they still are only confidence routines. In line with a real time system, redundant equipment and the present AUTODIN traffic handling concepts, the T&M's had five basic inadequacies.

1. They were function oriented

The T&M's tested functions in lieu of logic. This approach is inadequate for large matrices, as the testing of all permutable inputs is unwieldy.

2. They did not provide for stand-by operation.

In the AUTODIN System, a Monitor Dynamic Executive or AUTOMATIC Systems Monitor (ASM) determines if the redundant equipment is available for on-line status, when needed. This is accomplished by sending a "Stand-By" Pulse, under software control, from the redundant system to the ASM. The T&M's did not send this pulse, thus when running T&M's for confidence, the system was not in the Stand-By Mode and therefore logged down.

3. They did not localize faults

The T&M's did little to localize faults in the logic. The maintenance man could only determine where the fault was, if he previously knew exactly what that specific routine tested. In most cases this was a large amount of logic.

*"Stand-By" in AUTODIN is defined as the status of a Communications Data Processor (CDP) when it is delivering the specific stand-by pulse required by the Automatic System Monitor Logic for the stand-by status. The on-line production program can sense this condition and act accordingly.

4. Confidence.

Due to improper noise, crosstalk and worst case patterns, plus the fact that T&M routines test functions only, the confidence of the T&M's is questionable. Even if the T&M's run, it is by no means certain that the system can support the production program

5. Flexibility

The majority of the T&M's were written in machine language in lieu of assembly language. Therefore, they are difficult to comprehend, manipulate and change for a specific fault and for trouble shooting.

Recommendations

A feasibility study was performed to determine the merits of an AUTODIN automatic diagnostic system. A quote from a consultant, Dr. R. Goldman, reinforced our conviction that this system was superior to the T&M's[3]. His comments were:

On balance, the time and effort necessary to construct and implement a complete Diagnostic System with documentation will be well worth the improvement in reliability, the reduction in machine repair time, and the drop in failures which directly affect on-line operations.

Objectives of AAMP

As a result of the feasibility study the AAMP series was developed. Its five main objectives were:

1. To test the logic instead of the function,
2. To assure that the redundant equipment is operational, while maintaining the "Stand-By" state,
3. To localize faults
4. To use the AUTODIN Assembly language,
5. To increase the confidence factor.

In the development of AAMP, consideration was given to two important questions These are:

1. Malfunction Detection.
   What is the minimal test required to assure that no other test will fail?[1]
2. Localizing.
   Is it best to construct a set of tests that vary on preceeding failures to localize, or does one conduct all tests and then analyze the results to localize?

Malfunction Detection

When attempting to detect malfunctions in memory devices, patterns that develop maximum noise-to-signal ratio on the sensing lines or heads have proved to be most valuable. This pattern, usually referred to as a "worst case pattern" in magnetic core storage devices is easily obtained and depends on the physical layout of the cores. The following is a specific example of the development of an algorithm that will generate a worst case pattern for an AUTODIN linear select core memory.

Discussion with the design engineers revealed that the Worst Case pattern is as shown in Table I.

This table directly relates the memory addresses to the physical location of the cores. In order to develop the algorithm, one must determine how a change in the addressing bits affects the required pattern.

Careful scrutiny of the table revealed that the pattern changes from '1's to '0's because of a change of 2^5 bit in the address; therefore that 2^0 through 2^4 can be ignored. It can also be noted that the pattern reverts to '1's because of the presence of a '1' in 2^5 and 2^6, and a '0' in 2^8 Further analysis revealed that 2^7, and all address bits more significant than 2^8 address bits can be ignored. By referring these bits to Table I. another table can be developed

TABLE I

With the contents of all other addresses "0s", the following addresses should contain "1's" (All addresses are in octal notation.)

00000 to 00037	01000 to 01037	02000 to 02037	→	07000 to 07037	10000 to 10037	→	17000 to 17037	20000 to 20037 → 27000 to 27037	30000 to 30037	→ 37000 to 37037
00140 to 00177										
00200 to 00237										
00340 to 00377										
00440 to 00477										
00500 to 00537										
00640 to 00677										
00700 to 00737	01700 to 01737	02700 to 02737		07700 to 07737	11700 to 11737		17700 to 17737	21700 to 21737, 27700 to 27737	31700 to 31737	37700 to 37737

TABLE II

ADDRESS BITS			WORST CASE PATTERN
2[illegible]	2^4	2^5	
0	0	0	1's
0	0	1	0's
0	1	0	0's
0	1	1	1's
1	0	0	0's
1	0	1	1's
1	1	0	1's
1	1	1	0's

It can be seen from Table II that if there is an even number of '1's in the three significant address bits that the pattern is one's. This led to the following algorithm for the generation of 'worst case' or maximum noise-to-signal data pattern for this particular memory. Figure 1 is a flow chart, which indicates the steps in computing of a "Worst Case Pattern" for the particular AUTODIN core memory

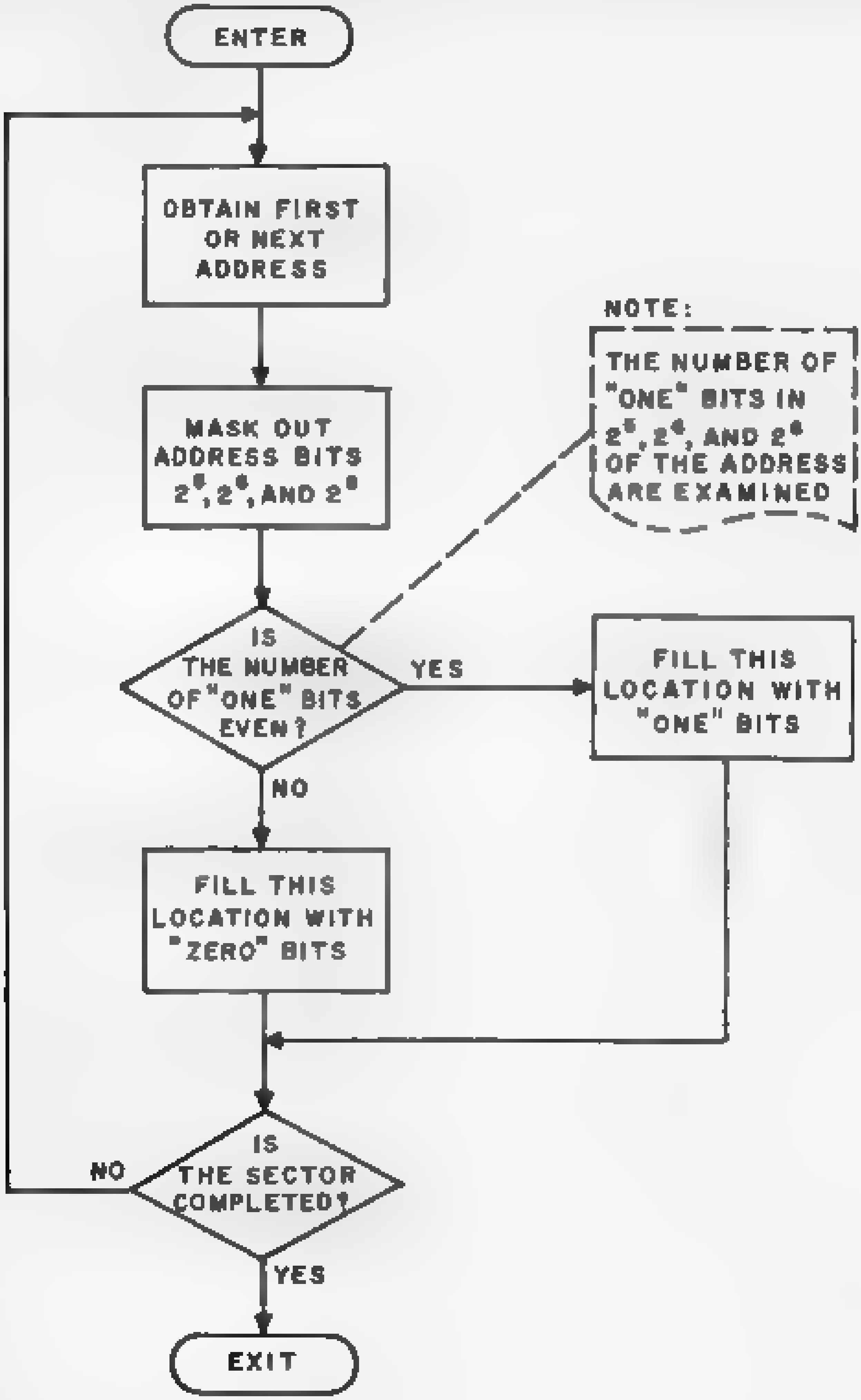


Fig. 1—Flow Chart—Worst Case Pattern

To verify logic matrices, and to obtain maximum aid in localizing a particular malfunction, it is best to test a minimum amount of logic as an increment. The only limitation on this minimum amount is the computer's ability to sense a particular signal from instructions. If a signal cannot be sensed by an instruction, then it becomes necessary to use external means.

In general, it requires n+1 tests to check a component with n inputs, it is not necessary to check all of the 2^n input combinations. It is sufficient to check only that each input can control the output.[3]

Of the possible tests for a three input "and" component, as shown in Figure 2 only four are necessary

Figure 2—And Functions

Necessary Tests

Test	Inputs A	B	C	Output D
1	1	1	1	1
2	0	1	1	0
3	1	0	1	0
4	1	1	0	0

Redundant Tests

Test	Inputs A	B	C	Output D
5	0	0	0	0
6	0	0	1	0
7	0	1	0	0
8	1	0	0	0

An expansion of Figure 2 is illustrated in a simple logic network, shown in Figure 3. The six input network has a total combination of 64 input possibilities. However, only nine tests are necessary to detect a malfunction in the network, and the remaining 55 are redundant

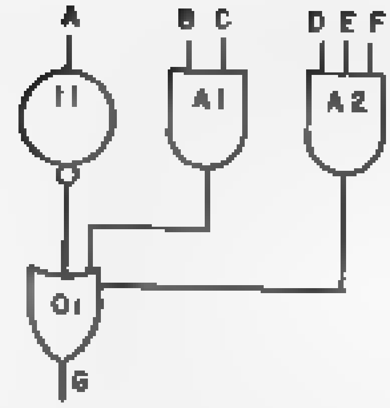


Figure 3—Simple Logic Network

Necessary Tests

Test	Input A	B	C	D	E	F	Output G
1	1	0	0	0	0	0	0
2	0	0	0	0	0	0	1
3	1	1	1	0	0	0	1
4	1	0	1	0	0	0	0
5	1	1	0	0	0	0	0
6	1	0	0	1	1	1	1
7	1	0	0	0	1	1	0
8	1	0	0	1	0	1	0
9	1	0	0	1	1	0	0

Localizing Faults

Due to the wide diversity of equipment in the AUTODIN System, AAMP uses two basic methods to localize faults

In the core memories, magnetic tape, drum and disc, a complete series of tests are run and malfunctions, if any, are logged for the purpose of analysis at the completion of the series.

In the Basic Processing Unit (BPU) of the Communications Data Processor (CDP) and in the control logic of the Accumulation and Distribution Unit (ADU), the success or failure of one test determines the next test to be run.[1]

It is believed that for maintenance aid programs that localize malfunctions the above will usually hold true Control logic will require a tree-like test structure, while memory devices will require the analysis of a complete series of tests.

AAMP Routines

AAMP is composed of the following nine routines

1. Executive or Control Program
2. Service Routines
3. Exercisor
4. Diagnostic Programs (6)
   - BPU Diagnostic
   - Memory Diagnostic
   - Drum, Disc Diagnostic
   - ADU Diagnostic
   - Magnetic Tape Diagnostic
   - Print Output Diagnostic

Executive or Control Program

This program is the executive program, it translates and evaluates all operator commands, and controls all other subservient programs as specified by the operator within the framework of the system philosophy

Service Routines

This set of routines perform normal AAMP library tape maintenance. They are used primarily for updating programs, patching and the insertion of new revisions.

Exercisor

This routine exercises all logic in the memories, BPU, ADU, and any other peripheral devices specified by the operator During exercising the 'Stand By' posture is always maintained. The operator can add or delete devices at will without affecting this posture. If, for any reason, the On-Line production program fails, or the operator specifies it, this program will automatically cease exercising and revert to the Control Program. The Control Program will then automatically read in the basic On-Line Production Program and the necessary environmental tables, causing this processor to assume the On-Line posture

If the Exercisor detects a hardware malfunction it will do one of two things depending on the mode of operation. This mode is specified by the operator and is changeable at any time. In the "automatic" mode, the Exercisor will generate a print out, drop the Stand-By posture and call in the appropriate diagnostic for localization In the "non-automatic" mode, the Exercisor will generate the printout as above, abort the present test, and continue with the next test.

Diagnostic Programs

These six routines listed above, are called in by the Control Program, and localize the malfunction to the smallest increment of hardware feasible. These programs make use of information logged by the Exercisor, and contain exercisor subroutines of their own. Output information is printed on a console printer, or displayed in a register if the hardware is incapable of printing

Output of AAMP

All outputs of AAMP are in the form of an 8 digit octal number. The 2 most significant digits are the specific number of the program that generated the printout and the 6 least significant digits are for detailed information. These printouts are referred to, in an instruction manual for decoding the information. Table III contains some examples of the printouts and the decoded information.

In Table III the left hand column is the only information printed at the console printer. If the processor is unable to print this information, it is displayed in a register. The information in the remaining columns is obtained from the AAMP Instruction Manual

For example The '01' in the most significant digits of the first 3 entries identify them as Exercisor output and thus do not contain detailed module information. The '02' and the '03' entries are for the Memory Diagnostic and ADU Diagnostic respectively

The Module Chart column contains both the location and the type of hardware module suspected. When more than one module is listed they are in preferential order. (In table III, printout 02007346, the module in slot E1 is more suspect of fault than E 10.)

Table III

SEVEN EXAMPLES OF AAMP OUTPUTS

Printout	Type of Failure	Module Locations	Chart Type	Cross References Pseudo Name	Flow Chart pg. no.	Drawing Number
01000053	Failed selective reset BAC	Call in BPU diagnostic		EXSELRT	10	—
01000515	Signal "SFFXSIT" does not set BAV flip flop with SITL present from AT transfer channel	Call in ADU diagnostic		ATXFERCKO5	25	—
01000114	Bad 'E' Bank	Call in Memory diagnostic		EXBAROUT	18	—
02007405	"E" Bank Suspect Boards associated with Signal Half Word 'A'	D 11	31A1	RORCKT5	D 33	86219 24
02007346	'D' Bank Suspect Memory Address Register Parity Bit and Associated Board	E 1 E-10	31A1 22A1	SWMAA2	M-4	86219 22 86219 24
03100300	No Signal "Reset CRY"	6-06-04 13	M826 1	CRREST	Z 11	AD090
03100104	Bad CCAR 2^4 and Associated Gating	6-03-02 20 6 03-04 19 6-03-02 22	M844 11 M826 1 M826 3	CCAR	Z 12	AD106

The three Cross References columns contain three items for the technician's use. The Pseudo Name identifies the sub-routine in question. The Flow Chart column indicates the page in the book of flow charts, and the Drawing Number is the actual hardware drawing for the suspected faulty module. These columns are of prime importance when the technician finds that the malfunction is not where the program indicates.

Success of AAMP

At the present time approximately 50% of the AAMP software is in the field, and the initial system package (35%) has been in operation for more than a year.

In light of the objectives mentioned above, the results of the AAMP System are most successful. The more significant results are as follows

1. *All tests have as their prime motive, the checking of hardware logic in the AUTODIN System, and not the machine functions.*
2. *The Exercisor maintains the Stand-By posture and does relinquish control of the hardware when needed by the On-Line Production Program.*
3. *At the start of the project it was the goal of the AAMP System to localize 85% of the AUTODIN hardware problems, with general area localization of 95%, and no solutions in no more than 5% of the malfunctions. The diagnostic programs that are in use do meet this original objective.*
4. *All coding is written in the AUTODIN Assembly Language, allowing easy changes when hardware is modified*
5. *The greatest AAMP success has been the confidence factor generated by the successful running of the Exercisor Program. To date, there have been no reported cases of successful Exercisor operation on hardware that was unable to support the On-Line Production Program.*

* * * *

References:

1. AUTODIN System Description, TECHNICAL REVIEW, H. Jansson, Part I—January, 1964, Page 38R; Part II April 1964 Page 68.
2. A study of the feasibility of an AUTODIN Automatic Diagnostic System by Dr R. Goldman, PP 20.
3. A Computer Organization and Programming System for Automated Maintenance, K. Maling and E. E. Allen IEEE Transaction on Electronic Computers, Volume EC-12, No. 5, December, 1963, PP 887-898.
4. AUTODIN Automatic Maintenance Program Instruction Manual

Mr. W R. LaBar, General Supervisor in the Technical Facilities Department, is responsible for directing the Maintenance Analyst Section and the development of maintenance diagnostics for Western Union computer systems.

Mr. LaBar, joined Western Union in June of 1960 and has been associated with many Western Union switching systems such as Plan 55 and AUTODIN. He has played a major part in the activation, integration and expansion of the AUTODIN Network. Under his direction and guidance, the AAMPS philosophy was created, developed and implemented to enhance Western Union's AUTODIN maintenance capabilities

He has an Electrical Engineering degree from Texas Technological College.

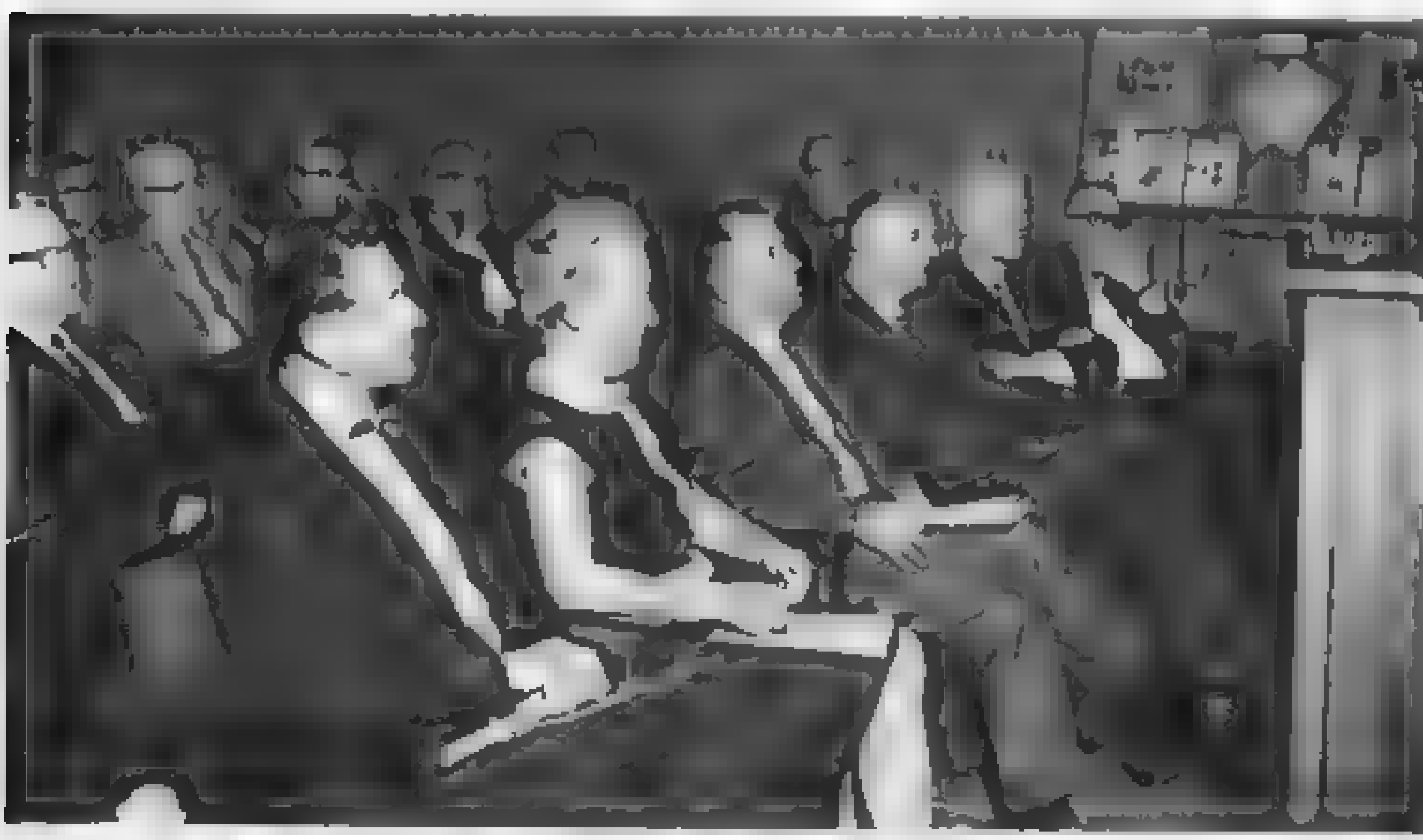
the 20th anniversary of our TECHNICAL REVIEW at our new technology center

Mary C. Killilea, Editor

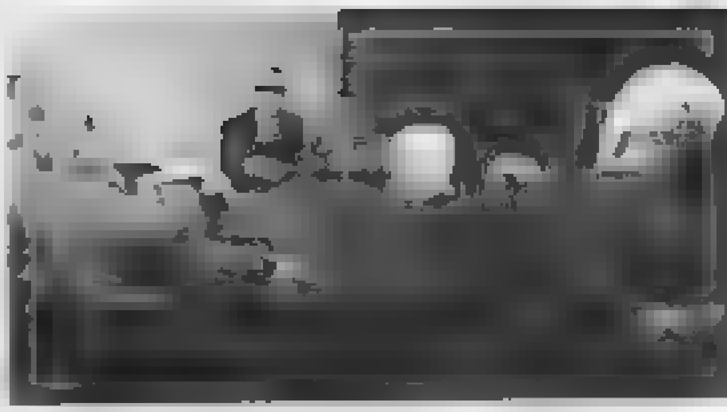
We did celebrate the 20th Anniversary of our technical publication on August 11, 1967 at our new Technology Center in Mahwah, N J. It was interesting to see the present organization of the New Western Union welcome those, now retired from Western Union, but still most interested in the new objectives of our Company

Invitations were sent to the First Committee on Technical Publication by book message over Telex. Four members of that first group were able to attend. The others are now residing all over the United States as far West as California

The 20th Anniversary issue of the TECHNICAL REVIEW was devoted to the developments of Western Union in satellite communications. Those authors responsible for much of the satellite development were introduced to the audience in the lecture hall as in tribute to their accomplishment. Among this audience were such celebrities as C. Godfrey Smith, George Oslin, Ivan S Coggeshall, Paul J Howe, the honored guest. These four were the only members of the First Committee on Technical Publication able to attend the celebration. However, G. Hotchkiss, A. E Frost, R. J. Duncan, C. B Young, Jr., members of subsequent committees, came to pay tribute to the Honored Guest Mr. Howe, and the members of the present Committee

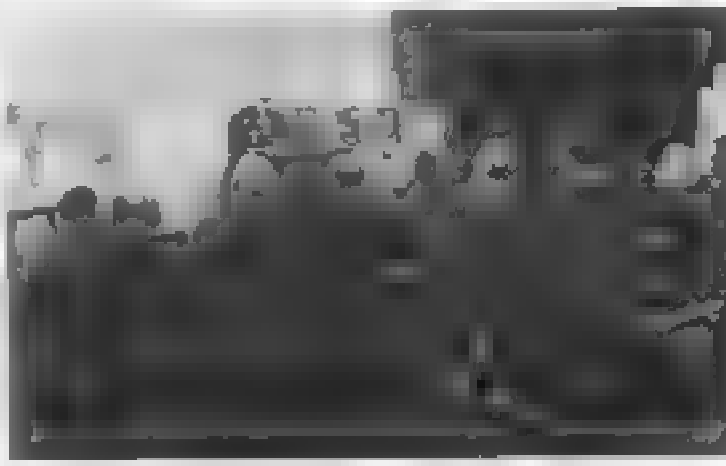


Mr. R. W. Hodgers, Jr., Vice President of Information Systems and Services, made the keynote address at the honoring ceremonies. He paid tribute to the Editor when he said "he remembered the day he met Mary K[illegible]ea, who indicated to him "that more could be done with the TECHNICAL REVIEW." Almost 50 people attended the meeting in the new lecture room at Mahwah, N.J. It was a most attentive audience that listened to Mr Hodgers expound on the future of communications in satellites



R. W. Hodgers, Jr.—Keynote Speaker

Mr. P. J. Howe, shown in the photo to the right, was the honored guest. He launched the TECHNICAL REVIEW 20 years ago and told the audience how he did it



P. J. Howe—Guest of Honor

When the present Chairman of the Committee on Technical Publication, Warren Fisher, reviewed the background of the magazine, he paid tribute to Mr. Howe and the First Committees for their foresight in providing a media for documenting our engineering know-how for the benefit of new Western Union employees

W. H. Fisher—Chairman of Committee on Technical Publications

It is interesting to discover as we review the membership of this Committee, that C. Godfrey Smith is the one member who retained his membership on the Committee on Technical Publication since its inception. This is a great tribute to his judgement of policies regarding a technical publication. When the

A tour, of the new Technology Center at Mahwah, N.J., was guided by Dale Beeninga, Assistant Vice President, shown in the group photo to the right. The honored guests were most interested to learn of the new SICOM service now being offered by Western Union and based at Mahwah

Honored Guests Tour New Technology Center

Congratulations to W. U. and the TECHNICAL REVIEW

Some of the "Letters to the Editor," commenting on the occasion of the 20th Anniversary, pay tribute to the advancements made at Western Union and to the significance of the TECHNICAL REVIEW.

Excerpts from a few correspondents follow:

1. **P. J. Howe**

   Our honored guest, Mr. P. J. Howe, First Chairman of the Committee on Technical Publication, was delighted to attend. He wrote "Please accept my sincere thanks for the honor and good wishes that you and yours extended to me—be sure that memories of that day will always be with me."

2. **Nell Ramhorst** could not attend the celebration. She was a member of the First Committee. However, when she read the August 1968 issue, she wrote, "The 20th Anniversary Issue was most impressive. I liked the cover particularly, of course, and the pictures of the Committee. But I'm afraid I'd be lost in the new arts and techniques of this space age."

3. **George Oslin** attended the celebration with great interest. He wrote, "The Mahwah Facility is a real eye-opener, and the tour alone made the trip worthwhile, but it also was a real pleasure to see so many old friends and to have an opportunity to meet some of your new associates.

   Sue and I wish to tell you again how very much we appreciate the many courtesies you, Messers. Beeninga, Burke, Fisher, Vincent, and others extended to us in connection with the observance of the twentieth anniversary of the TECHNICAL REVIEW."

4. **F. B. Bramhall** could not attend.

   He was Chairman, for over 14 years on the Committee on Technical Publication. But his letter from California to the Editor read: "I appreciate the invitation to the 20th anniversary celebration. Please pass on my regrets to all, particularly "P. J." The 20-yr. life is a real tribute to the usefulness of the publication. I should like to see Mahwah.
   Regards to you and all."

5. **H. M. Saunders**—a member of the first Committee on Technical Publications, sent a telegram from Pompano Beach, Calif. "Thanks for the invitation to twentieth anniversary of TECHNICAL REVIEW. Sorry cannot attend but please give our regards to Mr. Howe and other past and present members of the Committee.

6. **George Hillis**, Walkerton, Indiana, writes, "Of the present group, I recognize only four besides yourself,—but the magazine keeps getting better. When the magazine first started many of us felt it was not technical enough, but now after these many years, must of the technical descriptions are over my head —but I can get the general idea."

7. **T. E. SMITH**

   One of our customers, T. E. Smith of Automatic Electric, wrote, "It is a great pleasure to join with all the members of the communication fraternity in congratulating Western Union for its 20 years of splendid contribution to the industry through the pages of the TECHNICAL REVIEW.

   We wish to express our gratitude to you as publishers and our keen anticipation for the TECHNICAL REVIEW'S future issues."

Refreshments were served after the welcoming ceremonies. Russ McConnell, Assistant Vice President, in IS&S, shared the birthday cake with the honored guest, Mr. P. J. Howe, shown above on the right. The birthday cake displayed the first cover of the TECHNICAL REVIEW, an 8" x 11" format which was issued in July 1947. Pat Keppel, on the left, secretary to Asst. Vice President J. V. Burke, cut the cake.

Broadband Exchange Service
Data/Voice Communications Systems
CCITT

Wilder, H. F.: International Data/Voice Communications

Western Union TECHNICAL REVIEW, Vol. 21, No. 4 (November 1967)
pp. 174 to 183

Western Union provides an international data service over our Broadband Exchange Service, via the three overseas carriers, to patrons in Great Britain and Europe. This article cites the recommendations of the CCITT, of which Western Union is a member and shows how Western Union has cooperated with CCITT in data/voice communications.

Codes
Teleprinters

Smith, F. W.: Revised U.S.A. Standard Code for Information Interchange

Western Union TECHNICAL REVIEW, Vol. 21, No. 4 (November 1967)
pp. 184-190

The U.S.A. standard code for information interchange has been revised and was approved by the U.S.A. Standards Institute on July 7, 1967. The original ASCII code was described in the Western Union TECHNICAL REVIEW in April 1964.

The old and new control characters and their new definition are explained in this article. A new teleprinter Model 37 has been designed using the new dual case US ASCII code.

Glossary
Definitions

Glossary—Definitions of New Terms

Western Union TECHNICAL REVIEW, Vol. 21, No. 4 (November 1967)
pp. 191

Because of the many terms used in the computer-oriented telecommunications industry, the TECHNICAL REVIEW publishes a list of terms used in their articles on their new systems and services.

International Data Communications
Trends in Telecommunications

AMA Seminar on—

International Data Communications
pp. 192 to 193

At the AMA seminar in Sept. 1967 on International Data Communications some significant comments were made on the growth of Western Union's systems and its projected revenues for 1975. This article reviews a few excerpts from the seminar.

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SERVICE TO OUR READERS:
As a service to our readership, articles will be abstracted so that a complete file may be kept for future reference.

Software
Maintenance Programs
AUTODIN

LaBar, W. R.: AAMP—AUTODIN Automatic Maintenance Program

Western Union TECHNICAL REVIEW, Vol. 21, No. 4 (November 1967) pp. 194 to 201

AAMP, an acronym for the AUTODIN Automatic Maintenance Programs, is a series of programs in a software system developed to enhance the maintenance goal of AUTODIN. These diagnostic programs localize troubles in hardware logic and have been most successful. Approximately 50% of the AAMP software is in the field and the initial system package (35%) has been in operation for more than a year.

Anniversaries
Technology Center
Awards

Kilfilea, Mary C.—20th Anniversary of the TECHNICAL REVIEW

Western Union TECHNICAL REVIEW, Vol. 21, No. 4 (November 1967) pp. 202 to 205

Western Union's technical publication was published originally in July 1947—and has been documenting the engineering progress of the Company since that time. The anniversary of the publication was celebrated at the new Mahwah Technology Center on August 11, 1967. This article reviews some of the highlights of that celebration.

ANNOUNCEMENTS

- *New Subscription Rates for 1968*

Starting with the 1968 issues, new subscription rates for the TECHNICAL REVIEW will be $10 per year.
Some back issues are available at $2.50 per copy, with a $5 minimum order for back issues.